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Mohave Chub (*Gila mohavensis*) at Fort Soda, California

Habitat Management Plan

Prepared and Submitted by

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INTRODUCTION

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INTRODUCTION

Species account

The Mohave chub, Gila mohavensis, is a relatively large (to 30 cm. standard length) lqcustrine type minnow. This species is less streamlined than most chubs in Western North America. The color pattern of the Mohave chub is a uniform gold highlighted olive above grading to silvery white below. The Mohave chub can be distinguished from the closely related Owens chub (Gila bicolor snyderi) by its more numerous gill rakers. The pharyngeal teeth are weak with slight hooks and broad grinding surfaces adapted to grinding plankton, an unusual dietary specialization for fishes endemic to arid areas.

Gila mohavensis evolved in isolation in the Mohave River. It has now completely hybridized with the introduced arroyo chub (Gila orcutti) throughout the Mohave River proper (Hubbs & Miller, 1942). The only remaining genetically pure populations occur in two highly modified habitats at Fort Soda (formerly known as Zzyzx Springs) in the southeastern edge of the dry bed of Soda Lake, near Baker, San Bernardino County, California. The first collection of Mohave chubs at Fort Soda came from a concrete tank (Miller, 1938) that had been there since at least 1917 (Thompson, 1929). Mohave chubs have managed to survive through over fifty years of extensive alteration of aquatic habitats at Fort Soda. The present populations are probably derived from a naturally isolated ancestor, but the possibility of an introduction accounting for their occurrence at Fort Soda cannot be excluded.

Because of the unique qualities of the species and its range reduction to one highly modified series of springs, it was declared an endangered species in 1970 by the U.S. Department of the Interior through publication in the Federal Register Vol. 35 page 16047, 30 October 1970 and by the State of California in California Administrative Code, Title 14, Section 670.5.

Habitat Description and Analysis

The area under consideration in this Habitat Management Plan (HMP) includes all aquatic habitats, springs and ponds, in the immediate vicinity of Fort Soda in Section 11 (T12NR8E) in eastern San Bernardino County, California (Figure 1). A thorough field reconnaissance of all aquatic habitats failed to discover any new populations of Mohave chub nor any springs or ponds deemed capable of supporting a population.

Three habitats in the vicinity of Fort Soda now support populations of Mohave chub and will be considered in this HMP. The aerial photograph (Figure 2) gives a good perspective of the relative size, configuration and physical relationship of the three habitats. The largest habitat is a shallow man-made pool (Lake) supplied with water entering via a centrally-located fountain from a nearby well. The other large habitat is a wedge-shaped pond (Pond) filled by natural seepage and spring flow, lying approximately 50 meters to the southwest of the Lake. The third habitat is a small, tule choked spring lying approximately 150 m south of the east end of the Lake. The physical description, vegetation and water quality of each habitat will be considered separately.

.45 ha = 1.11ac

Lake -- The Lake is a man-made pool 30 X 150 m, with the long axis running east-west. The Lake is shallow, with a thick layer of sediment from organic decay, windblown soil and debris washed in by floods. The Lake has a maximum depth of 110 centimeters (cm) near the northeast corner (Figure 3). The west end is heavily silted in, largely from debris entering during a flood in September 1976. The western third of the Lake is less than 50 cm deep over approximately 60% of the area, while the center third is more than 65 cm deep over approximately 50% of the area and the eastern third is more than 80 cm deep over 80% of the area. All depths were measured to the top of the solid sediment. Adult Mohave chubs (>10 cm total length [T.L.]) were primarily found in water over 80 cm deep, whereas juveniles (<8 cm T.L.) were almost always in water less than 50 cm deep.

Figure 1. U.S.G.S. 15' topographic map of Fort Soda and surrounding area.

N
S
S
L
2
1
BM 930
11
Soda Springs
(Alkali)
12
BM 937
14
13
Spring
(Alkali)
20
21
23
24
BM 966
26
VABM 945
Devils
25
28
27
29
Rasor Ranch
778
852
Well
31
32
33
34
35
36
BM 893
SAND
6
5
4
3
2
1

Figure 2. Aerial photograph of Fort Soda. The three Mohave chub habitats are labeled. (David Soltz)

Date of photo?

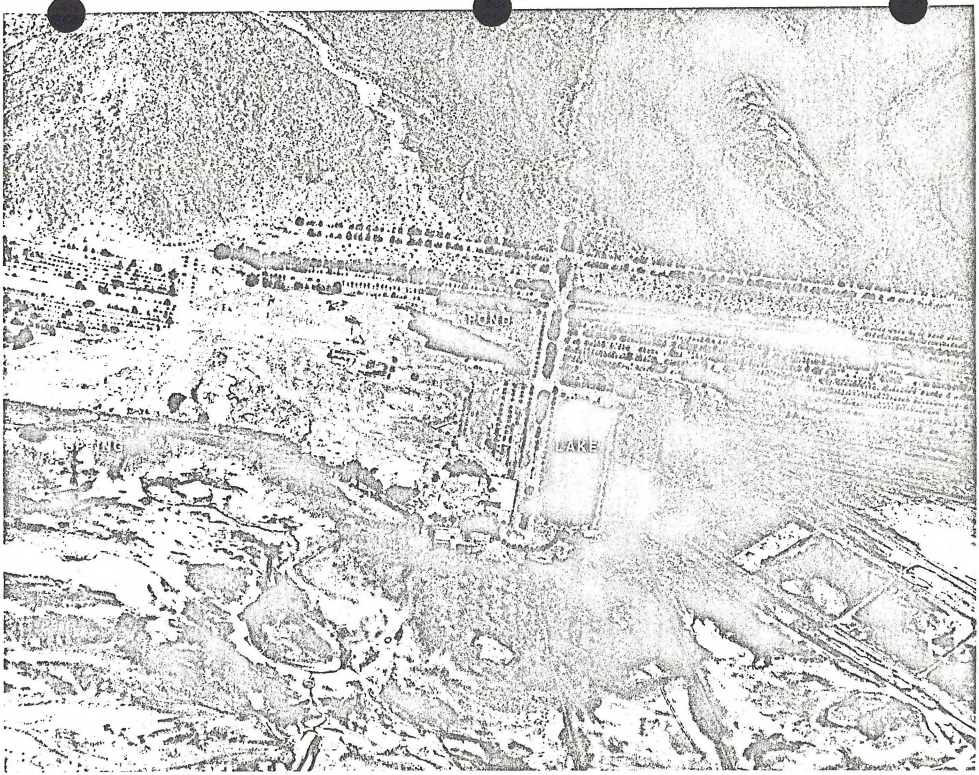
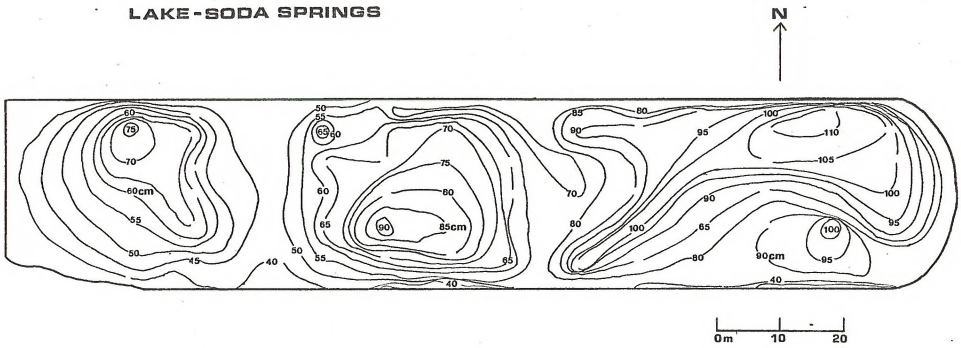

LAKE

Figure 3. Depth contour map of Lake habitat.

LAKE-SODA SPRINGS



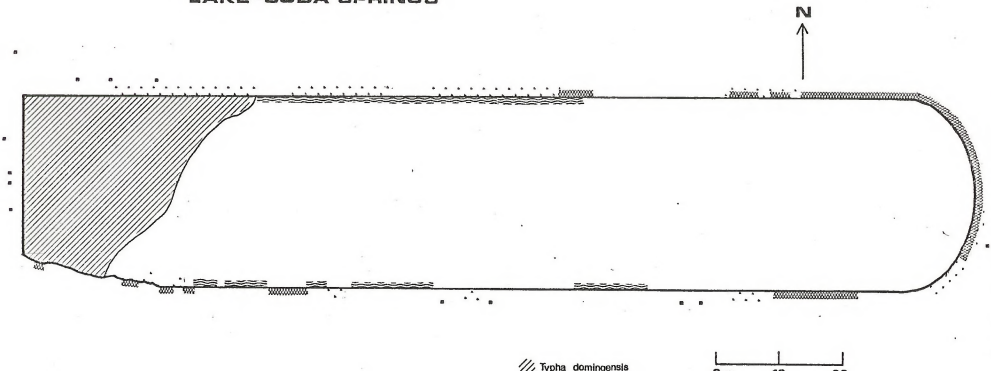
The Lake has no natural water source. Water pumped from a well adjacent to the Pond, enters the Lake from a centrally-located rock fountain. Pumping water through the fountain both cools and aerates the water and this method of filling the Lake should be continued. The fountain should flow continuously, day and night, particularly during the hot months to compensate for the tremendous evaporation rate ~~of the habitat~~.

The emergent and shoreline vegetation consisted of only five species: Distichlis spicata, Typha domingensis, Scirpis olneyi, Juncus cooperi and Tamarix sp., in decreasing order of shoreline coverage. Figure 4 is a distribution map of the vegetation around the Lake. Most of the shoreline is unshaded with Distichlis spicata growing into the water. Occasional Tamarix sp. and the dock in the center of the east end provide the only shade over open water. Typha domingensis has encroached well into the west third of the Lake since the 1976 flood and is continuing to overtake shallow open water habitat (see Figure 4). This rapid encroachment of Typha is a part of the natural succession of shallow aquatic habitat. It must be controlled to provide adequate open water habitat for the Mohave chub population.

The Lake habitat supported a dense growth of the rooted aquatic plant Ruppia maritima, throughout the initial study, July to September 1977. Thickness of the Ruppia bed varied from 20 to 60 cm, reaching the surface in most of the western third of the Lake. Percent coverage of Ruppia was estimated by dividing the entire habitat into 10 X 10 m squares, visually estimating coverage in each square and averaging. On August 6 percent coverage was 86% and the Ruppia was actively growing throughout the habitat. On September 20, however, percent coverage had decreased to 60%, approximately half of the Ruppia was dead or dying and the eastern third had only 25% coverage. Apparently September was the beginning of the seasonal die-off of Ruppia maritima which contributes significantly to sedimentation of the Lake. It may be good management practice to remove much of the dying Ruppia before it decays, however, Ruppia should not be elim-

Figure 4. Vegetation map of Lake habitat.

LAKE-SODA SPRINGS



inated as it provides an important microhabitat in the hot summer months (see below).

Surface Lake water temperatures are summarized in table 1. Data are from the hottest part of the year. Maximum temperature recorded was 33.3°C and maximum daily range was 9°C from 22.2 to 31.1°C. Stratification data were gathered from 35 randomly placed stations. Data are presented here only for August 6, 1977, the hottest day of the study when air temperature reached 44°C. On that day there was no stratification at 0700, water temperatures ranged from 25 to 27°C throughout the habitat. At 1600 maximum stratification was a 12°C difference, with surface temperatures varying from 34.6 to 36.5°C and bottom temperatures varying from 25 to 27°C. It is evident that bottom temperature does not vary, even on very hot days. Ruppia has a significant insulating effect. Mean temperature drop from open water to 20 cm into the Ruppia bed was 2°C and 5°C at 40 cm into the bed.

Dissolved oxygen levels never reached critically low levels, day or night, on any of the 16 days spent in the field during the initial study. While there was considerable microhabitat variation, which is not presented here, daytime (0500 to 1900) levels ranged from 8.5 to 15 ppt. Most values were at super-saturation levels due to the tremendous O_2 evolution from photosynthesis of the dense Ruppia bed. Night (1900 - 0500) levels were also high, ranging from 5.3 to 10 ppt.

There was one very significant exception to the general pattern, in the tea-stained water within the Typha bed dissolved oxygen levels never exceeded 8 ppt and dropped to from 1 to 3.6 ppt during the night. Three minnow traps were routinely set over night in this area. Most traps were empty when collected between 0500 and 0700, of the eleven Mohave chubs that entered these traps at night all died, surely of anoxia. This is another good reason for curtailment of Typha encroachment and eventual removal associated with deepening of the Lake habitat. Do you have a permit to take?

Table 1. Summary of Lake water temperatures taken 10 cm below the surface off the end of the dock, taken daily between August 22 and September 15, 1977.

Time	0700	1700
$\bar{x}$	24.8°C	30.8°C
range	22.2-26.7°C	26.7-33.3°C
max. daily range	22.2-31.1°C (9°C) on 8/28	
min. daily range	25.5-29.4°C (4°C) on 8/22	

Water analysis was not budgeted in the initial study and could not be carried out with our Hach Kit due to high water temperatures. pH was periodically checked at our trap stations where it varied from 8.9 to 9.8 These values correspond closely to those found by La Bounty (1968). This range of pH appears to have no effect on Mohave chubs.

Pond -- The Pond is also a man-made pool. Original dimensions were approximately 70 X 40 m, with the long axis running north-south. Debris washed in by flash floods over the years has filled approximately 30% of the Pond in the north and west portions, resulting in the present wedge-shaped pond habitat (Figure 5). This habitat has a natural water source from seepage from the alluvial fan to the west and reportedly from at least one spring flowing in near the center of the south end. The bottom of the Pond slopes from a maximum water depth of only 25 cm near the north end to 80 to 90 cm at the south end. A hole 2.5 m deep and approximately 3 m in diameter near the old pump house in the southwest corner is not shown on the map. The north half of the Pond is less than 60 cm deep throughout. Adult Mohave chubs were rarely captured in water less than 50 cm deep and very few chubs of any size were taken in water shallower than 30 cm.

The only emergent plant species in the Pond was Scirpis olneyi, distributed as shown in Figure 6. Occasional Tamarix sp. were growing around the edge with many small seedlings along the northern third of the west shore. A tall stand of arrow weed, Pluchea sericea, above the western two-thirds of the south shore provides some shade. No Distichlis spicata was growing along the shoreline of the Pond, where as it was the dominant plant of the Lake shoreline.

The bottom of the Pond contains a layer of 30 to 100 cm of black, anoxic sediment, sealed over by a one to three cm layer of fine, brown mud and presumably petroleum residues. The long (over 20 years) period of operation of a power plant up-slope from the Pond provided conditions for entry of diesel fuel spillage into the Pond. Some petroleum residues are certainly incorporated into the substrate

Figure 5. Depth contour map of Pond habitat.

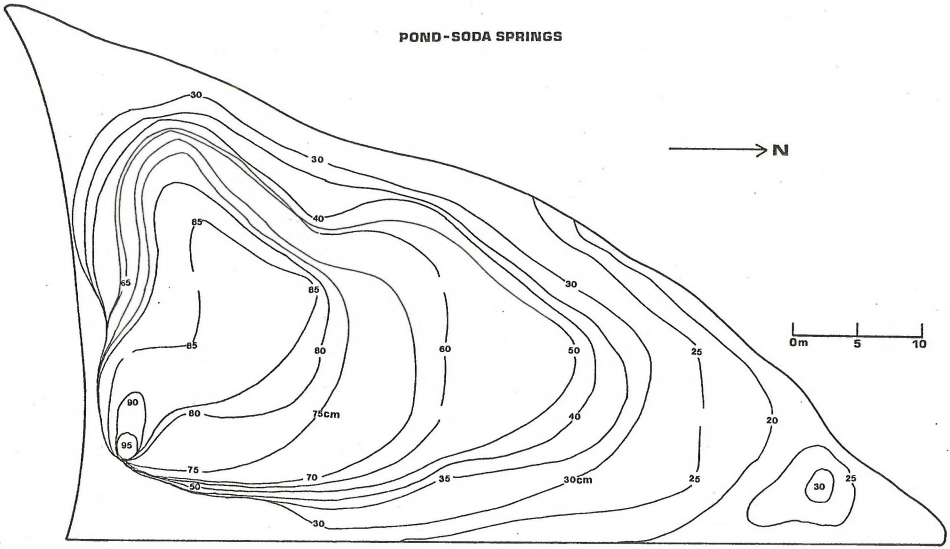
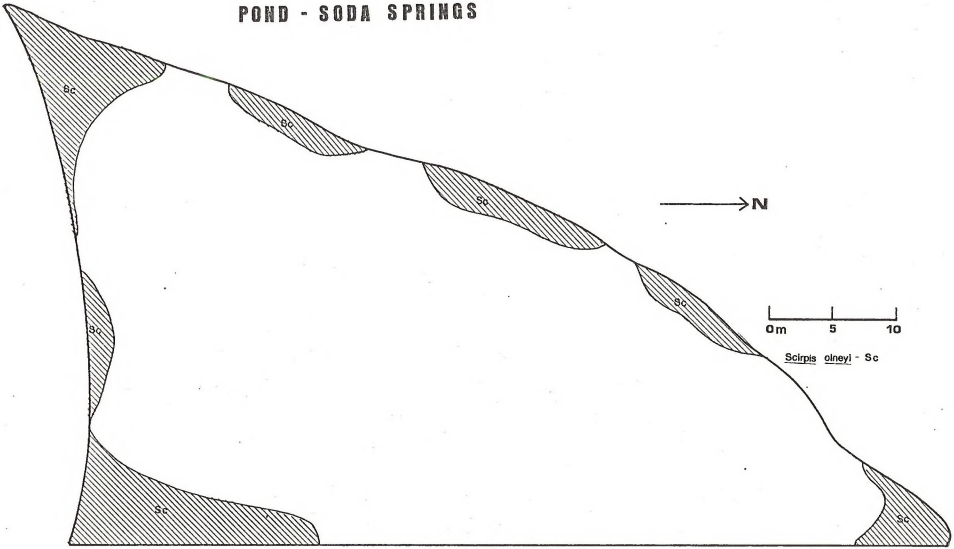

POND-SODA SPRINGS
N
0m
5
10
30
30
40
85
65
85
85
80
60
50
25
90
80
75cm
40
20
95
75
70
35
30cm
25
30
25
50
30

Figure 6. Vegetation map of Pond habitat.

POND - SODA SPRINGS



of the habitat. These residues may account for the virtual absence of Ruppia maritima from the Pond. A few scattered patches of Ruppia, all less than 2 m in diameter, occurred in water less than 60 cm deep. - Why not show them in the fig.?

Thermograph recordings taken continuously throughout the study, from a location 50 cm below the surface in 80 cm of water, varied from 25 to 31°C with a maximum daily range of 4°C. Stratification data are summarized for 7 August 1976. At 0800 there was no stratification, water temperatures varied from 23.5 to 25.5°C at 31 stations throughout the habitat. At 1700 stratification was greatest in water 80 to 90 cm deep. Maximum difference was 9°C, with bottom temperatures of from 23.5 to 24.5°C and surface temperatures from 31 to 33°C. There was no stratification in water less than 30 cm deep, where all temperatures were from 31.5 to 32.5°C. Almost no Mohave chubs were captured by seining shallow habitat at these high temperatures and seven chubs in minnow traps were dead. It appears that chubs leave water of temperatures above approximately 30°C which may be lethal.

Dissolved oxygen readings from twelve trapping stations randomly located throughout the Pond showed greater variability than did Lake D.O.s, ranging from 7.0 to 14.8 ppt during the day and from 6.2 to 10.6 at sunrise (0500-0530). The highest readings were from stations located in or near patches of Ruppia. The early morning readings were all above critical values and no Mohave chubs died in traps overnight.

pH was uniform throughout the Pond at 8.4 to 8.5, somewhat lower than in the Lake. No other water quality data were taken on the Pond.

Spring -- The Spring habitat was completely choked with Typha domingensis and Scirpis olneyi, there was no open water. The Spring "pool" was approximately 3.5 m in diameter, and 2 to 2.5 m deep under a complete layer of Typha roots and runners. The Spring had been enlarged in the past. On 21 August, three minnow traps baited with bread were placed in the Spring at 0900 and removed at 2000.

Three Mohave chubs were trapped. The chubs were 6.5, 8.5 and 10.0 cm standard length. Water temperature was 26°C and D.O. was 6.8 ppt at 2000. A small population of Mohave chub persists in the Spring habitat.

Pupfish Populations

Pupfish populations present in both the Lake and Pond habitats at Fort Soda are Cyprinodon nevadensis nevadensis, introduced by a former land user in 1955 (Turner & Liu, 1976). Pupfish prefer shallow water, with open substrate and water temperatures above 25°C. Consequently they are largely confined to a strip of habitat extending less than one meter from shore. Pupfish did leave the shoreline habitat to feed in the shallow warm layer over the dense Ruppia bed in the western third of the lake. They have little overlap with Mohave chub of any size class, which all prefer cooler, deeper water. Pupfish are opportunistic omnivores feeding largely on the bottom, whereas Mohave chubs are planktivorous, as indicated by various trophic apparatus, although no stomach content data are available (Soltz and Naiman, 1978). Competition for food is probably not a significant area of overlap. Pupfish are known to include fish and invertebrate eggs in their diet. They are probably not a significant predator on Mohave chub eggs, however, due to their avoidance of deeper water where the chubs presumably spawn.

The pupfish population in the Lake numbered approximately 3300 in late September 1977, based on a Schnabel estimate with a 95% confidence interval from 2850 to 3879. There were numerous active territorial males and many juveniles in their shoreline habitat. In contrast, less than 40 pupfish were collected during intensive seining of the Pond and all were adults. The Pond pupfish population was too small to accurately estimate and perhaps is no longer reproducing in that disturbed habitat, lacking in aquatic vegetation.

Population Dynamics and Life History

No studies of Mohave chub life history or estimates of population size had been carried out prior to the study upon which this HMP is based. The short period of the field study, three months during the summer season, restricted the amount of data obtainable. Continuation of these studies is essential to understanding factors influencing growth and reproduction of the Mohave chub population. Such information is needed to successfully manage these habitats and provide optimal conditions for survival of the Mohave chub.

Population Estimates--Various sampling methods were used in obtaining the population estimates. In the Pond most fish were collected by seining and some minnow trapping was done. In the Lake seining was not possible because of the dense growth of Ruppia. Chubs were collected from the Lake by minnow trapping and using an umbrella net baited with bread. All minnow traps were also baited with bread. Both Peterson single mark-recapture and Schnabel multiple mark-recapture estimates were performed.

Population estimates for each habitat are presented in Table 2. All estimates of the Lake population are for the larger size classes, because no fish under 6 cm standard length were marked, only these larger fish tended to enter the umbrella net and they concentrated in the deep water off of the dock where umbrella net samples were taken (Figure 7). Minnow traps were even more biased in that they only sampled fish between 6 and 12 cm standard length. Adequate mixing of marked fish is indicated by data showing that in a recapture sample of 492, 33% had moved a distance of 25 to 100 meters in 24 to 48 hours. Consequently, Lake population estimates using umbrella net samples only are biased and indicative of the large size classes only (fish largely over 9 cm standard length).

The Lake population estimate of 2744 and the Pond estimate of 1170 provide the best comparison as both are reasonably accurate estimates of the adult

PETERSON ESTIMATES OF MOHAVE CHUB POPULATIONS AT SODA SPRINGS

Interval Dates	Lake Estimate	Lake 95% C.I.	Pond[C] Estimate	Pond[C] 95% C.I.
7/16 - 7/17	2744[A]	2135 - 3525		
	1538[B]	1091 - 2257		
8/6 - 8/7			1170	946 - 1413
9/23 - 9/25	1062[B]	915 - 1248		
9/22 - 9/24			12818	10430 - 14565
9/17 - 9/24			14524[D]	12396 - 17008

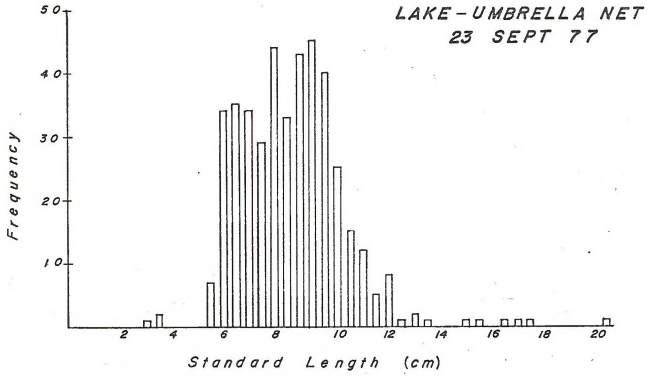
A Trap and umbrella net sample

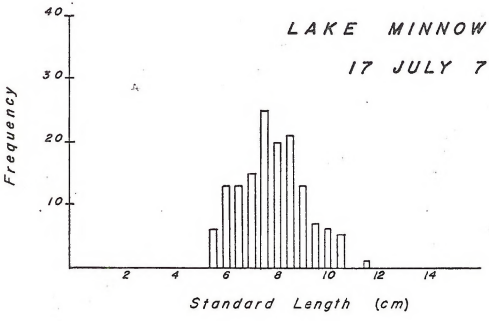
B Umbrella net sample only

C Seine samples

D Schnabel estimate $N = \frac{\Sigma(C_T M_T)}{\Sigma R_T + 1}$

Figure 7. Length frequency distributions of Mohave chubs from the Lake habitat, based on two different sampling techniques.


LAKE - UMBRELLA NET
23 SEPT 77
Frequency
50
40
30
20
10
2
4
6
8
10
12
14
16
18
20
Standard Length (cm)


LAKE MINNOW TRAPS
17 JULY 77
Frequency
40
30
20
10
2
4
6
8
10
12
14
Standard Length (cm)

(> 6 cm standard length) populations. These estimates indicate the adult reproductive population in mid-summer was twice as large in the Lake as in the Pond.

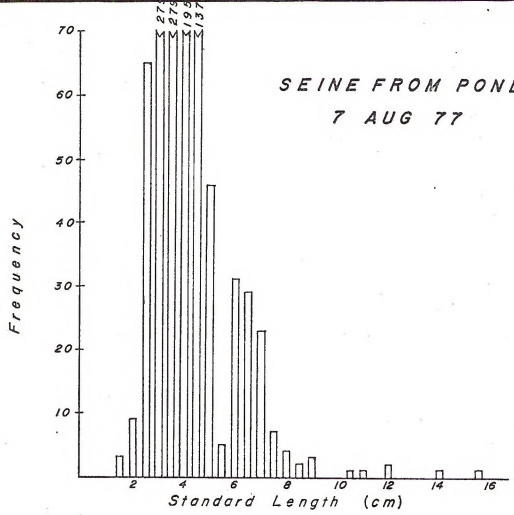
The September estimates of the Pond population are very large, a Peterson estimate of 12818 and a Schnabel estimate of 14524, and do not differ significantly. In obtaining these estimates individuals down to 4 cm standard length were marked. Virtually all chubs collected were over this size. The 4 to 5 cm size class was extremely large and represented the new (1977) year class (Figure 8). These estimates are indicative of the entire Mohave chub population of the Pond at a time when most of the young of the year have just reached collectable size. Although it was not possible to effectively collect chubs less than 6 cm standard length in the Lake (see Figure 7), schools of thousands of 4 to 6 cm individuals were observed. Certainly the total Mohave chub population in the Lake was two to three times that of the Pond.

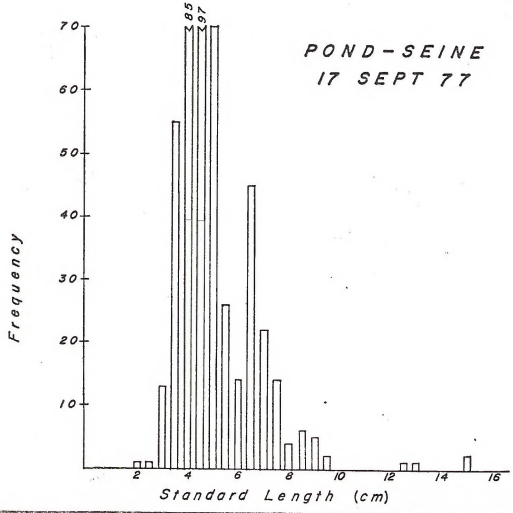
Due to complete lack of knowledge of the size of the Mohave chub populations or the condition of their habitats at Fort Soda prior to this study, no preserved samples were taken. Preserved samples are needed to determine other life history parameters, such as age to maturity, fecundity and sex ratio, essential to the successful management of stable populations of Mohave chub at Fort Soda. These samples would also provide useful information about food habits and requirements of the Mohave chub. The population estimates for both the Lake and the Pond habitat are large enough that a monthly sample of 50 chubs could be taken from each habitat with no deleterious effect on the populations.

Optimum Habitat Conditions

Based on data gathered in my initial study, conditions needed to be maintained in order to have optimum habitat for Mohave chub (Gila mohavensis) are:

Figure 8. Length frequency distributions of Mohave chubs sampled from the Pond habitat by seining in August and September 1977.


SEINE FROM POND
7 AUG 77
Frequency
Standard Length (cm)


POND-SEINE
17 SEPT 77
Frequency
Standard Length (cm)

1. Constant water supplies to both habitats, with backup systems.
2. Water temperature conditions such that large areas of habitat remain below 30°C.
3. Over 50% of the habitat should be over one meter deep - to provide temperatures below 30°C, and feeding and spawning habitat for adult Mohave chubs.
4. Dense stands of Ruppia maritima should be present in water less than one meter deep - to provide temperatures below 30°C and habitat for juvenile Mohave chubs.
5. Dissolved oxygen concentration that does not fall below 4 ppt.
6. Water quality that supports a large, stable planktonic food chain.

Management procedures necessary to maintain these conditions are detailed in the Habitat Management Plan.

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PART II

HABITAT MANAGEMENT PLAN

Objectives
Rationale
HMP Outline
HMP Narrative
Selected Management References

MOHAVE CHUB, GILA MOHAVENSIS, AT FORT SODA, CALIFORNIA

HABITAT MANAGEMENT PLAN

Objectives

The primary objectives of managing the habitat of the Mohave Chub at Fort Soda are:

1. To restore the Mohave Chub to non-endangered status and to maintain the species in that classification.
2. To develop and/or restore two habitats at Fort Soda that will maintain stable populations of Mohave Chub permanently, with minimal maintenance and manipulation by man.

The following additional objectives are pertinent to the realization of the primary objectives.

1. To establish separation of the waters in the two habitats to assure independence of the two populations of Mohave Chub in the event of loss of water supply, eutrophication, chemical pollution, introduction of disease, or other potentially harmful alterations of one of the habitats.
2. To establish a water supply for at least one of the habitats that does not require continual or even periodic pumping of water into the habitat.
3. To develop additional information on the factors controlling population-growth and dynamics of Gila mohavensis, and carrying capacity of the habitats at Fort Soda.
4. To inform the public of the value of maintaining this unique species at Fort Soda.
5. To post the habitats at Fort Soda with legal and interpretive information.

RATIONALE

The Mohave Chub, Gila mohavensis, naturally occured throughout the lower reaches of the Mohave River. The species has introgressively hybridized with an introduced chub, Gila orcutti, in all flowing sections of the Mohave River proper. The only "genetically pure" populations of G. mohavensis presently occur in three habitats lying within 150 m of each other at Fort Soda, near Baker, California. Whether they are relictual populations that have survived drastic habitat manipulations or are introductions of G. mohavensis into man-made habitats is problematical and will probably never be resolved. Regardless, the habitats at Fort Soda support the only viable populations of the endangered Mohave Chub and must be restored and maintained to perpetuate the species.

MOHAVE CHUB, GILA MOHAVENSIS, HABITAT AT FORT SODA, CALIFORNIA

HABITAT MANAGEMENT PLAN OUTLINE

I. Develop and restore two existing pond habitats at Fort Soda.

A. Lake habitat - now supports a healthy, reproducing population, that can be maintained with relatively little management.

1. Install separate pump on water source to insure continual input and aeration of water.
2. Curtail encroachment of Typha on west end of Lake. - how? Be specific
3. Plan to dredge organic debris from this shallow habitat, at periodic, long intervals, with minimal effect on Mohave chub population.
4. Monitor physical and chemical parameters of water quality.
5. Monitor size of chub population over a two year period. Gather life history data at this time.
6. Further document distribution of age classes and sexes in the Lake.
7. Determine daily and seasonal patterns of movement of Mohave chub in the Lake.
8. Determine spawning season and conditions necessary for successful spawning.
9. A design for future redevelopment of the Lake should be based on information in items 5-8 above.

B. Pond Habitat - habitat is degraded, yet still supports a large Mohave chub population.

1. Develop habitat into a deep pond of optimal conditions for Mohave chub.

a. Remove chub populations to holding cages in Lake habitat.

b. Pump water from Pond. This will eliminate the small pupfish population. Not reintroducing the pupfish would be valuable as an experiment in later population-dynamics studies on the reintroduced chub population.

What is legal status of this sp.?

c. Take water samples and core samples of bottom sediment to determine extent and distribution of contamination with petroleum residues.

d. Enlarge Pond to approximate dimensions of 70 x 50 x 1.5 m with steep banks

(1) remove all petroleum residue if possible, by digging pond down to alluvial gravel, which entails removing 0.5 to 1.0 m of sediment from existing pond.

(2) steep banks will discourage Typha growth.

e. Increase natural seepage or spring flow into pond, if possible, to maintain Pond without reliance on pumping.

f. Introduce aquatic vegetation and invertebrates from Lake to promote rapid reestablishment of natural food chain.

2. Reintroduce G. b. mohavensis after pond has stabilized from improvement operation.

a. Monitor population growth of reintroduced Mohave chub population.

(1) Introduce population of known size (age) distribution.

(2) Monitor population growth monthly; taking demographic data as well. Follow Lake population simultaneously for comparative purposes.

b. Follow establishment of food chain and effects of expanding chub population on food chain.

(1) Monitor primary productivity.

(2) Monitor invertebrate food availability.

(3) Take periodic chub samples for stomach content analysis.

c. Monitor physical and chemical parameters of water quality.

d. Install permanent water level marker in each habitat and provide equipment for daily monitoring of surface and bottom temperature by the on-site caretaker.

II. Spring habitat - three Gila mohavensis were trapped in a small, tule choked spring lying approximately 150 m south of the east end of the Lake.

A. Remove emergent aquatic vegetation from spring.

B. Trap fish to determine population size.

C. Remove emergent vegetation annually to keep spring pool open.

D. Introduce additional fish from Lake to augment population, if necessary.

E. Monitor population size.

F. Possibly enlarge spring pool area to improve conditions for Mohave chub population.

III. Post all three habitats at Fort Soda with attractive, permanent signs with informative and protective information.

IV. Develop material for public information and education on the value of Mohave chub habitat management at Fort Soda.

A. Produce a brochure similar to that on the Unarmored Threespine Stickleback (copy attached).

B. Develop a slide presentation with a taped narrative, similar to that produced by BLM, Reno on the Warm Springs pupfish at School Spring, Ash Meadows, Nevada.

NARRATIVE FOR THE MOHAVE CHUB AT FORT SODA
HABITAT MANAGEMENT PLAN OUTLINE

Two separate habitats at Fort Soda presently support large, reproducing populations of Mohave chub (Gila mohavensis). Both habitats are man-made and will have to be managed in order to provide optimal conditions for survival of the Mohave chub. Lack of management could lead to rapid silting and drying of both ponds. This would result in extripation of the Mohave chub from the last habitat in its native Mohave River drainage. Fort Soda is now under the direct control of the Bureau of Land Management and the California Desert Studies Consortium which greatly facilitates the management, monitoring and thus the survival of the Mohave chub in these habitats.

I,A) The Lake habitat is a diverse, fairly stable ecosystem that contains the largest and healthiest of the populations. It apparently has contained a Mohave chub population longer than the other habitats at Fort Soda. The main management problem is that this habitat has no natural water source and depends on water pumped through a central fountain from a nearby well.

,A,1) The well which provides water for the Lake is also used for irrigation of the introduced, landscape vegetation on the site. When the irrigation system is in use no water flows from the fountain into the Lake. A separate pump should be installed in the well to insure continual input of aerated water into the Lake. An additional back-up pump would be a safeguard assuring that a breakdown of the primary pump would not result in serious lowering of the water level during the summer months. Continued use of the fountain as the point of water input is recommended. The action of the fountain aerates the water and partially compensates for low dissolved oxygen concentration in some regions of the Lake on hot summer nights.

A,2), A,3) The Lake is gradually filling with sediment from organic decay, windblown soil and debris washed in by flooding after heavy rains. Debris washed into the

west end of the Lake in September, 1976 decreased water depth to approximately 30 cm for five to 15 meters from the shore. Cattail (Typha domingensis) which had been restricted to patches along the shoreline, had covered the entire shallow area by June, 1977 and was continuing to encroach. Water in the dense stand of cattails is shallow, low in pH, low in productivity and becomes essentially anoxic at night in hot weather. However, many Mohave chub move into this shaded, cooler water on hot summer days. The overall effect of cattail encroachment is reduction of habitat.

Cattails should be controlled by cutting the entire stand off at the water level in the Fall of each year. This management practice should reduce the density of the stand and curtail encroachment, while still providing some shaded water which may be beneficial to the Mohave chub population. If encroachment continues under this low intensity management, the cattail marsh should be eradicated by removing all roots and runners using mechanical means. Such a major eradication should be part of a general redevelopment scheme to be discussed in section I,A,8.

Slower siltation is occuring throughout the rest of the Lake due to accumulation of organic debris and windblown soils, a natural process of succession in shallow aquatic habitats in arid areas. Present sediment build-up varies from 10 to 70 cm in an irregular pattern throughout the Lake. This debris must be periodically removed to preserve the Lake as suitable habitat for Mohave chub. Reportedly the previous user of the area last dredged the Lake, using hand labor, in 1968 or 1969. The Lake was partially drained and no attempt was made to provide undisturbed or alternate habitat for the Mohave chub. Although no mortality data is available there presumably was a significant loss, however, obviously enough chubs survived to reestablish a large population. Judging from these experiences I recommend a program of regular (annual?) hand removal of debris in areas of greatest accumulation (perhaps areas

with more than 75 cm of sediment). If performed in late winter (February), before the spring increase in productivity, the impact on the Mohave chub population should be minimal.

(I,A,4), (I,A,5), (I,A,6), (I,A,7) A complete analysis of physical and chemical parameters of water quality should be performed in 1978 to establish baseline conditions in both the Lake and the source well. Thereafter, a regular monitoring program employing routine measurements of dissolved oxygen, pH, and temperature should establish weekly fluctuations over a one year period. Continued management would involve a less frequent monitoring program whereby abnormal changes in the three basic water quality parameters can be detected and rectified.

(I,A,5) Population size should be monitored bimonthly until a predictable annual cycle is established for the prevailing habitat conditions. Thereafter semi-annual population estimates should be made at times of predicted population maximum and minimum to monitor for deviations from the predicted cycle. Standardized techniques using a modified Schnabel mark-recapture estimate over a four day period are recommended. Various sampling techniques, including minnow trapping, seining, and umbrella net capture should be used in all micro-habitats to obtain a random sample of all size classes throughout the habitat. Partial clipping of one fin is an effective mark which is detectable over a short period. However, fish under 6 cm total length cannot withstand the handling necessary for marking and thus estimates of the juvenile size class cannot be made using standard techniques. If time precludes carrying out a Schnabel estimate, a Peterson estimate, which takes two days, using similar techniques would be adequate although less desirable.

While carrying out the bimonthly population estimates all individuals should be measured (total length), providing data for length-frequency histogram analysis of size (age) classes. Subsamples of the different size classes should be weighed. These data would allow estimation of average growth rates and condition of the

different size classes of Mohave chub.

(I,A,6), (I,A,7) Continuation of the study carried out in June-September 1978, using minnow traps set at various depth and microhabitats in the Lake would provide information on seasonal and daily movement patterns and microhabitat utilization of the different size classes of Mohave chub. The initial study suggested that larger individuals selected deeper, cooler, areas w/dense vegetation on hot summer days. The fry and juveniles, however, were concentrated in shallow, warmer water. Firm documentation of these patterns is essential before this habitat can be redeveloped to provide optimal conditions for the Mohave chub.

(I,A,8) Population monitoring studies, detailed above, also should provide information on the spawning season of the Mohave chub. Chub fry were present from June through September, 1978, the period of the initial study. This suggests an extended spawning season. Once the peak of the spawning season is determined, observations of spawning behavior and location of spawning should be made. Sampling of vegetation and substrate in spawning areas would yield information on specific sites of egg deposition. Comparison of numbers of eggs spawned in the habitat with egg counts from individual dissected ovaries would establish reproductive potential of different size classes of female Mohave chub.

(I,A,9) The Lake is a habitat that is now and will continue, on the short term, to support a large population of Mohave chub. However, after the studies detailed in sections I,A,5-I,A,8 have been carried out enough information will exist to redevelop the Lake, creating optimal conditions for long term management and survival of this Mohave chub population. Sufficient data to design the redeveloped habitat can and should be gathered over the next two to three years.

The Pond habitat has a natural spring water source and supports a large population of Mohave chub. The habitat is, however, in a degraded condition; and continued support of a healthy chub population is questionable. The water was continually turbid brown during the initial study. The bottom consists

entirely of a slick layer, possibly composed of petroleum residues, which seals a substrate of from 30 to 100 cm of black, anoxic sediment. Ditch grass (Ruppia maritima) covers only approximately 5% of the Pond bottom, in contrast to > 90% coverage of the Lake bottom.

(I,B.1) I recommend that this habitat be immediately redeveloped into a deep pond, approximately 50 x 70 meters and 1.5 m deep throughout. In reconstructing this habitat biological, chemical and physical parameters should be manipulated to optimize the environment for growth, reproduction and survival of a Mohave chub population.

(I,B,1,a) A rescue operation, employing both seining and trapping, should be carried out to capture and remove as many Mohave chub as possible from the Pond prior to redevelopment. Rescued fish should be held in large, mesh holding cages (approximately one cubic meter in volume) placed in the Lake. Chubs from the Pond should not be released into the Lake as that would disrupt a fairly stable population and surely exceed the carrying capacity of the Lake environment. Approximately ten holding cages would be needed and the rescue operation should take a team of six people about two days. The redevelopment of the pond should then proceed immediately to minimize the period of holding chubs at high densities in the cages.

(I,B,1,b) The next stage in redevelopment would involve draining the Pond by pumping to facilitate enlargement and reconstruction using a bulldozer. The fish rescue operation should continue as the pond is drained. The small introduced population of pupfish (Cyprinodon nevadensis nevadensis) will be eliminated by these procedures and should not be reintroduced. Removal of the pupfish would allow investigators to follow growth of the reintroduced Mohave chub population and establishment of a carrying capacity of the redeveloped habitat in the absence of their introduced potential competitor and egg predator.

(I,B.1,c) Complete analysis of water samples from the existing Pond, the spring source

and the redeveloped Pond should be carried out. This will allow detection of both beneficial and detrimental changes in water chemistry resulting from redevelopment of the habitat.

It will be very important to take a series of core samples of Pond bottom sediment and analyze them to determine the extent and distribution of contamination with petroleum residues. The historical operation of Zzyzx strongly indicates that spillage and leakage of diesel fuel from the power plant routinely entered the Pond. This may have been a significant factor leading to the degraded condition of the Pond habitat.

(I,B,1,d), (I,B,1,e) Prior to enlargement and reconstruction of the Pond, the natural seepage and spring inlets should be found. Attempt to enlarge natural flow by use of hand digging tools or possibly blasting, if necessary. This natural flow development will necessitate continual pumping of water during reconstruction.

A bulldozer (skip-loader) and dump truck should be able to enlarge the pond in one day. It will be necessary to dig down to the alluvial gravel, which will entail removing 0.5 to 1.0 m of sediment, and hopefully all petroleum residue, from the bottom of the existing Pond. Shaping the pond to approximate dimensions of 70 x 50 m, with the long axis running north-south, will also entail removing extensive amounts of dirt and rock that now fill the northwest corner of the pond. All banks should be cut at a steep angle (approximately 1-1/4 to 1) and compacted to prevent encroachment of emergent aquatic vegetation, particularly Typha. Bank shaping will probably involve some hand labor.

(I,B,1,f) The pond should be allowed to refill immediately after enlargement is completed. As soon as the water clears in the enlarged pond, large scale introductions of aquatic vegetation (primarily Ruppia) and invertebrates from the Lake should be made. This will promote rapid reestablishment of the natural food chain and accelerate redevelopment of a stable ecosystem including the Mohave chub.

This redevelopment operation will produce a habitat for the Mohave chub with

a natural flowing water source that is designed to maximize growth and reproduction of the population. While it is highly desirable to have separate water sources for the Lake and Pond habitats, to assure independence of the population in the event of contamination of one habitat, a backup pump and water system from the well supplying the Lake should also enter the Pond. This system would only be used in the emergency situation of sudden failure of the natural water inlets to the Pond.

(I,B,2) Mohave chubs should be reintroduced into the enlarged Pond from the holding cages as soon as possible. Rapid reintroduction will reduce mortality from extended holding at high density in the cages. The reintroduction will surely occur before a stable food chain and abundant density of prey species for the chub is reestablished. This situation will require repeated reintroduction of invertebrates from the Lake and possibly supplemental feeding with trout chow.

(I,B,2,a) For reasons of assuring rapid growth of the population and to facilitate collection of data concerning factors governing growth and reproduction of Mohave chubs, I recommend that not all rescued chubs be reintroduced into the pond. Rather, the introduced population should consist of a known size (age) distribution similar to the size structure of the more stable population in the Lake. Reintroduction of all chubs removed prior to redevelopment would surely exceed the carrying capacity of the new enlarged Pond habitat. Starting the population with a known size distribution will greatly facilitate investigation of population growth rates and the factors involved in establishment of a stable age distribution. The exact size and composition of the introduced population should be determined by a knowledgable investigator at that time. Population size should be monitored monthly for the first year following reintroduction and bimonthly thereafter until the population stabilizes with a predictable annual cycle. Maintenance of this stable population growth cycle should continually be monitored by semiannual population estimates. Standardized techniques, as

detailed in section I,A,5, using a Peterson estimate or preferably a Schnabel estimate, should be used.

(I,B,2,b) It would be very useful for future management to follow, (a) establishment of the food chain in the Pond, (b) effects of the expanding Mohave chub on the food chain, and (c) simultaneously gather similar data from the more stable Lake ecosystem. Primary productivity should be monitored on a monthly basis using standard light-dark bottle techniques. Simultaneous monitoring of invertebrate prey availability would involve a standardized scheme combining zooplankton net, bottom grab and vegetation subsamples combined w/identification of organisms to family and classification by microhabitat type. Periodic (bimonthly) samples of Mohave chub (approximately 20 per sample) must be taken for stomach content analysis, using a modified point system, to determine general feeding habits and electivity of available prey. It may be possible to use a stomach aspirator on individuals over approximately 15 cm total length and thus decrease the number of chubs sacrificed.

(I,B,2,c) Beginning immediately after redevelopment, a regular monitoring program employing routine measurements of dissolved oxygen, pH, and temperature should establish weekly fluctuations over a one year period. Thereafter, a less frequent monitoring program, whereby abnormal changes in the three basic water quality parameters can be detected and rectified, is suggested.

(I,B,2,d) Install permanent water level reference markers in both habitats. Provide a telethermometer with a 10 foot probe and two Ryan submersible recording thermographs for monitoring of water temperature in both habitats. This equipment could be part of that necessary to establish a full weather station at Fort Soda. One criterion for the caretaker/manager position should then be the knowledge and ability to take and record daily weather, water temperature and water level data.

(II During the initial study, three Mohave chubs were trapped in a small, tule

choked spring lying approximately 150 m south of the east end of the Lake. The emergent vegetation should be removed, initially by hand cutting, and the size and extent of the habitat determined. Population size should be determined by trapping and mark-repcature estimate if necessary. Depending on the size, or even continued presence, of the chub population in the spring, introduction of additional Mohave chub to this habitat should be considered. Size of this population should be monitored on a bimonthly basis. Removal of most emergent vegetation on an annual basis, in late winter (February), should keep the spring pool open and maintain it as a viable habitat for Mohave chub. After establishing the annual population cycle, enlargement of the spring pool to increase the carrying capacity for Mohave chub should be considered.

This third, very small habitat for Mohave chub at Fort Soda should definitely be maintained and monitored. This habitat is another refuge for this endangered species. Study of the spring will reveal information about growth and survival of a Mohave chub population in a habitat that may resemble the natural environment at Fort Soda before alteration by man.

(III) All three Mohave chub habitats at Fort Soda should be posted with attractive, permanent signs containing informative and protective information. I do not feel that fencing of the habitats or other such extensive protective measures are warranted because the Fort Soda site is under the direct control and protection of the California Desert Studies Consortium. Suggestions for wording of the signs will be discussed at the consultation meeting with agency representatives in late April, 1978.

(IV) A program of public education on the Mohave chub, need for management of its essential habitat at Fort Soda, and the general values of this and all endangered species should be instituted. This program could be greatly facilitated by the member campuses of the California Desert Studies Consortium. Production of an illustrated brochure, similar to that on the Unarmored

Threespine Stickleback, is recommended. A slide presentation on endangered species habitat management at Fort Soda, similar to that produced by BLM, Reno on the Warm Springs Pupfish at School Spring, Ash Meadows, Nevada, also should be prepared.

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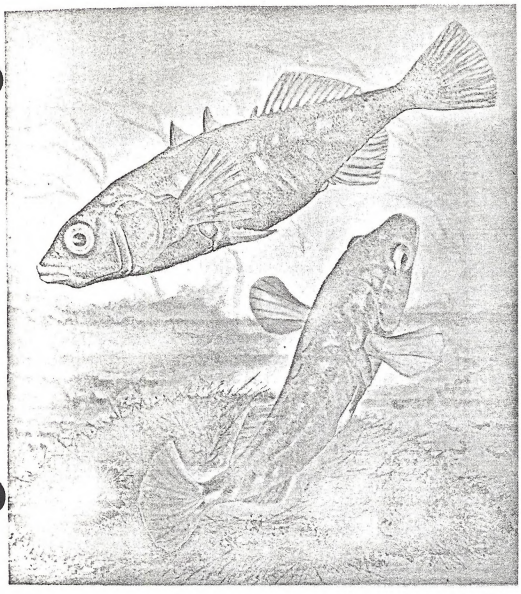
Attachment to Minute Order #1



THE UNARMORED THREESPINE STICKLEBACK

an endangered freshwater fish

The unarmored threespine stickleback, a small scaleless fish found in the upper reaches of the Santa Clara River system in Los Angeles County, is poised precariously on the brink of extinction. It is a victim of urbanization.

In 1917 this subspecies of the threespine stickleback was reported to be abundant in the Los Angeles, San Gabriel and Santa Ana River systems of the Los Angeles basin.

But today these rivers have been reduced for the most part to concrete-lined drains, and the last self-sustaining population of unarmored threespine sticklebacks is confined to the Soledad Canyon section of the Santa Clara River and a few of its small tributaries.

Although the fish is relatively abundant in the Santa Clara, anything that threatens the ecological stability of the river system threatens the continued existence of this particular subspecies.

Because of this precarious situation, the unarmored threespine stickleback has been placed on the endangered species list by both the federal government and the Fish and Game Commission of the state of California.

The threespine stickleback *(Gasterosteus aculeatus)*—translate this as *Gasterosteus* = "belly bone" and *aculeatus* = spined—is a small inconspicuous fish with a compressed, spindle-shaped body covered with a few bony plates or shields in place of scales. Mature individuals may grow to about four inches in length, but a three-inch stickleback would be considered big.

Sharp spines precede the dorsal and ventral fins. The mouth is small, with a projecting lower jaw. The color is greenish or olive above, grading to silvery on the lower sides and belly.

The species is found throughout the northern hemisphere, south to Southern California and north Africa. Three subspecies are recognized in California:

The northern threespine stickleback *(Gasterosteus aculeatus aculeatus)* is fully armored with plates along the sides. It is found in the ocean and brackish water south to central California.

The West Coast threespine stickleback *(Gasterosteus aculeatus microcephalus)*—translate that word as "small head"—is partially armored with plates. It is widespread in the fresh waters of California.

The subject of this pamphlet, the unarmored threespine stickleback *(Gasterosteus aculeatus williamsoni)*, is usually unarmored, or it may have two or three anterior plates. It is named for Lt. R. S. Williamson who first col-

lected it in the mid-1800s while surveying for a western railroad route. Some biologists believe this stickleback lost its protective armor because of the lack of predatory fishes in the upper reaches of the river systems where it made its home.

Food for the threespine stickleback consists of small aquatic organisms, primarily insects and crustaceans. Algae are also eaten.

The reproductive and parental behavior of this small fish has provided valuable insights about animal behavior generally. The male threespine stickleback (including unarmored ones) first assumes ownership of a territory from which he excludes other sticklebacks. At this time the male changes from his normal drab greenish brown and silver to a beautiful overall pale blue with the throat a brilliant red and the eyes irridescent blue. This coloration will last throughout the reproductive season. He builds a nest consisting of a small mound of decayed strands of plant material held together by a special substance secreted from the kidney. Because of its delicate construction and parental responsibilities that will eventually follow, the nest is located in slightly flowing but not stagnant water, generally near submerged plants. Most nests have been found in small ponds or pools that have a slow flow of water through them. The nest is completed when the male moves through the nest making a cavity where the eggs will be deposited by the female.

The male continues the defense of his territory but begins to court females with ripe eggs. They are recognized by their swollen stomach and lack of bright colors. The male expresses his interest by performing the zigzag dance. A receptive female responds by tilting her head up. The male leads her to his nest where he induces her to deposit her eggs and he fertilizes them. One nest may contain the eggs of more than one female, and one female may spawn several times from the late spring to early fall.

The male assumes the paternal responsibilities of protecting the nest from hungry predators and insuring an adequate flow of water over the eggs by alternately fanning and repairing the nest and chasing intruders out of his territory. A slow flow of clean water is needed for the eggs to develop properly. The eggs hatch after about days and the fry leave the nest after a short period of time. A male may raise veral broods in a reproductive season, which is concentrated in spring and early summer. The vegetation along the shore provides a protected hiding place for the very young fishes.

Obviously, a natural river system is essential to the survival of the threespine stickleback, and especially is this so with the unarmored threespine stickleback that is now confined to the Santa Clara.

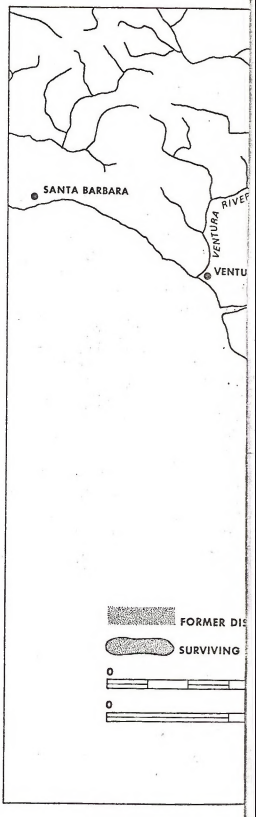
The native vegetation in the river bed and the formation of meanders along the Santa Clara River provide the proper conditions for the unarmored threespine to carry out its life cycle. If the vegetation is destroyed and the barriers, which create the pools in which most breeding takes place, are broken down, the ability of the stickleback to reproduce is diminished. Sticklebacks cannot survive in concrete-lined channels.

Another possible threat to this fish is the introduction of exotic species such as the African clawed frog which now exists only a few miles from the Santa Clara.

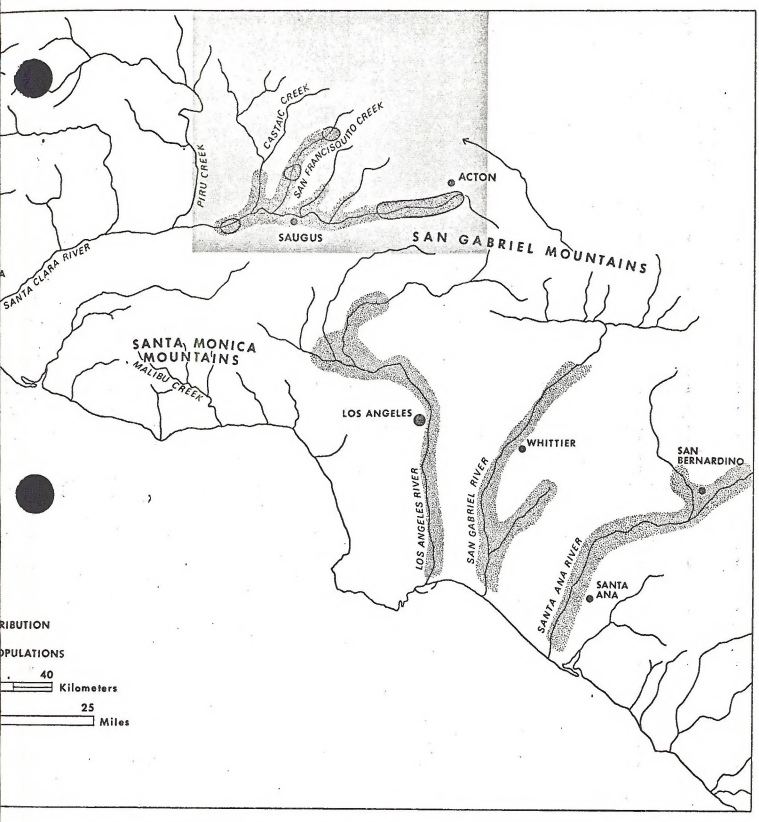
Is it important the unarmored threespine survive?

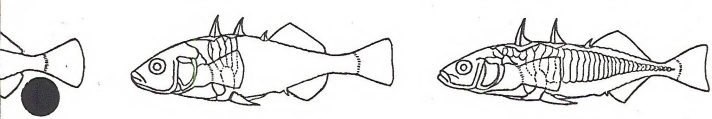
If it were an evolutionary death due to natural changes, perhaps not. But in this instance it would be a death hastened by the artificial contrivances of man. A small—perhaps important—link in the chain of life would be broken. Lessons to be learned from absence or presence of armored plates, for example, might be lost forever.

Attention is focused on the stickleback because it is obviously depleted, but it is in danger because of the deterioration of the lowland riparian habitat in which it lives. Thus it is an indication to us that something is wrong, and that special effort is required to protect and preserve the habitat which has been eliminated in the other places the fish once occurred. This means maintaining the wild habitat and not just removing a few fish to an aquarium or pond so the last habitat can be destroyed. To continue to destroy such remaining habitats will ultimately leave them without enough habitat for his own survival, and he would become threatened as well.



UNARMORED





PARTIALLY ARMORED

ARMORED

UNITED STATES LAW PROTECTING UNARMORED THREESPINE STICKLEBACK

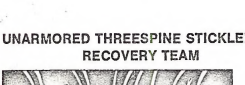
Public Law 93-205, also known as the Endangered Species Act of 1973, gives full protection to the unarmored threespine stickleback as an endangered species. This act also has provisions for land acquisition, for conservation of endangered species and provides for cooperation with the States in the management of endangered species.

CALIFORNIA LAW PROTECTING UNARMORED THREESPINE STICKLEBACK

Section 5515 of the California Fish and Game Code declares the unarmored threespine stickleback a fully protected fish. Fully protected fish or parts thereof may not be taken or possessed at any time and no provision of this code (the Fish and Game Code) shall be construed to authorize the issuance of permits or licenses to take any fully protected fish and no such permits or licenses heretofore issued shall have any force or effect for any such purpose, except that the commission may authorize the collecting of such species for necessary scientific research.

The Forest Service is authorized to enforce all fish and wildlife laws on National Forests.

UNARMORED THREESPINE STICKLEBACK RECOVERY TEAM



SECTION OF FISHES
NATURAL HISTORY MUSEUM OF LOS ANGELES COUNTY
900 EXPOSITION BLVD.
LOS ANGELES, CA., 90007

INLAND FISHERIES BRANCH
CALIFORNIA DEPT. OF FISH AND GAME
350 GOLDEN SHORE
LONG BEACH, CA., 90802

Bureau of Land Management
Library
Bldg. 50, Denver Federal Center
Denver, CO 80225

THE RECOVERY TEAM

In 1970 the unarmored threespine stickleback was listed as an endangered species by the U.S. Fish and Wildlife Service, and in 1972 the California Fish and Game Commission included it in the state's first list of rare and endangered species. In the spring of 1973 an ad hoc interagency team was formed to consider the status of this fish. Members of the team included representatives from the California Department of Fish and Game, the U.S. Fish and Wildlife Service, the U.S. Bureau of Land Management, California Polytechnic State University, Pomona, and Los Angeles County.

This interagency team recommended a study of the distribution, habitat and biology of the unarmored threespine stickleback. In the spring of 1974 Dr. Jonathan Baskin, Department of Biological Science, California State Polytechnic University at Pomona did the study with funds from the U.S. Fish and Wildlife Service.

The study confirmed the opinion of team members and advisors that the only pure strain of this subspecies is restricted to an eight- to nine-mile stretch of the Upper Santa Clara River in Soledad Canyon. Most of this stretch of the river goes through private lands, but a part of it is within the Saugus District of the Angeles National Forest. Although in dry years the flow of the stream may be intermittent, sticklebacks are able to survive in puddles and ponds of the streambed.

Other activities of the ad hoc committee included attempts to establish sticklebacks in other Southern California waters and a determination of the status of an exotic species, the African clawed frog, which has established itself in the Santa Clara River drainage, and might prey on sticklebacks.

In late 1975, the official Unarmored Threespine Stickleback Recovery Team was established by the U.S. Fish and Wildlife Service. Membership is essentially that of the ad hoc committee that preceded it.